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Sir:

Transmitted herewith for filing is the Patent Application of:

Inventors: **Christian Lita**  
For: **USING VIRTUAL URLs FOR LOAD BALANCING**

Enclosed are:

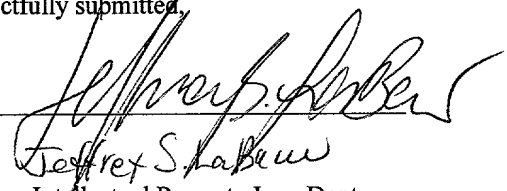
- ☒ Patent Specification and Declaration
- ☒ 3 sheets of drawing(s). (Informal)
- ☒ An assignment of the invention to International Business Machines Corporation (includes Recordation Form Cover Sheet).
- ☐ A certified copy of a \_\_\_\_ application.
- ☐ Information Disclosure Statement, PTO 1449 and copies of references.

The filing fee has been calculated as shown below:

For	Number Filed	Number Extra	Rate	Fee
Basic Fee				\$760.00
Total Claims	22-20	2	x \$18 =	36.00
Indep. Claims	6-3	3	x \$78 =	234.00
Multiple Dep. Claims Presented			x \$260 =	0
TOTAL				\$1030.00

- ☒ Please charge my Deposit Account No. 09-0447 in the amount of \$1030.00. A duplicate copy of this sheet is enclosed.
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  - ☒ Any patent application processing fees under 37 CFR 1.17.

Respectfully submitted,

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## USING VIRTUAL URLs FOR LOAD BALANCING

## BACKGROUND OF THE INVENTION

## Technical Field

This invention relates generally to information  
5 retrieval in a computer network. More particularly, the  
invention relates to a method and system for balancing HTTP  
requests to a set of servers on a per-session as opposed to  
per-connection basis.

## Description of the Related Art

10 The World Wide Web is the Internet's multimedia  
information retrieval system. In the Web environment,  
client machines effect transactions to Web servers using the  
Hypertext Transfer Protocol (HTTP), which is a known  
application protocol providing users access to files (e.g.,  
15 text, graphics, images, sound, video, etc.) using a standard  
page description language known as Hypertext Markup Language  
(HTML). HTML provides basic document formatting and allows  
the developer to specify "links" to other servers and files.  
In the Internet paradigm, a network path to a server is  
20 identified by a so-called Uniform Resource Locator (URL)  
having a special syntax for defining a network connection.  
Use of an HTML-compatible browser (e.g., Netscape Navigator  
or Microsoft Internet Explorer) at a client machine involves  
specification of a link via the URL. In response, the  
25 client makes a request to the server identified in the link  
and, in return, receives in return a document or other

object formatted according to HTML. A collection of documents supported on a Web server is sometimes referred to as a Web site.

At many popular Web sites, the capacity demand is much greater than can be served by one server. Thus, it is known in the art to mirror a Web site and to incorporate a load balancing routine to distribute connection requests across a pool of servers. Typically, such load balancing is carried out in a round-robin fashion. Each server preferably includes the same data, so any request can be handled by any of the multiple servers in the pool. This distributes the load in an even manner.

While such known load balancing schemes are advantageous, certain types of Web server transactions are not conducive to load balancing in this manner. Thus, for example, assume that the Web site is a financial institution or bank. Typically, a user accesses such a site to effect a set of one or more transactions, e.g., an account balance inquiry, a transfer of funds between a set of pair of accounts, and the like. When this type of site is mirrored for load balancing purposes, there is a likelihood that the user's HTTP requests will be serviced by different servers in the server pool. This is undesirable, and it may force the user to have to log-in repeatedly to complete all of the transactions required. Similar problems are

encountered in mirrored sites that offer electronic commerce transactions.

This problem arises because prior art load balancing techniques operate on a per-connection basis. Thus, if a  
5 given server handling an HTTP request suddenly becomes overloaded due to an excessive number of connections, the load balancing routine automatically delivers a next connection request to another server in the pool, even if the request originates from the same client machine.

10 The present invention addresses this problem.

**BRIEF SUMMARY OF THE INVENTION**

It is a primary object of this invention to provide a method for equitably distributing client requests across a set of servers on a per-session basis. Preferably, a given  
5 server in the set is allocated a given number of sessions, as opposed to a given number of connections, and thus a user's HTTP connection requests are preferably serviced from the same server in the set throughout the session.

It is another primary object of this invention to  
10 implement a load balancing routine across a set of servers wherein given connection requests originating from a client machine are serviced from the same server in the set.

A still further object of the present invention is to manage HTTP connection requests from a client machine using  
15 a so-called virtual URL that defines a user session. The client is then notified that that the requested URL has been moved to a specific server.

Yet another object of the present invention is to balance connection requests to a pool of servers on a  
20 session basis so that each server has a predefined number of users that may obtain access to documents supported on that server.

It is still another object of this invention to redirect HTTP connection requests originating from a user of  
25 a given client machine to a specific server during a session.

These and other objects of the invention are provided in a method, computer program product and server for use managing connection requests to a pool of servers identified by a given URL. In one embodiment, the method begins in  
5 response to a connection request from a given client machine that initiates a user session. In response to the request, the method associates a session identifier with a given server in the pool. The session identifier is then used to generate a "virtual" URL that redirects the connection  
10 request to the given server. Thereafter, any additional connection requests issued from the given client machine during the user session are redirected to the given server so that all content is served to the client from the same location. When the user session terminates, the virtual URL  
15 is inactivated and the given server is returned to the pool so that it can then be assigned a new user session to manage.

Thus, according to the invention, a method for managing connection requests to a pool of servers is responsive to  
20 connection requests from client machines that initiate user sessions for associating each user session originating from a client machine with a given server in the pool. User sessions are associated with the servers in the pool in accordance with a load balancing protocol. During each user  
25 session, any additional connection requests originating from a given client machine are then redirected to the server that is managing the session. The user session is

associated with a given server by generating a virtual URL that includes a unique session identifier, which identifier is then provided with all data returned from the server to the client machine. The virtual URL is inactivated upon  
5 completion of the user session.

The invention also describes a server for managing a pool of servers at a Web site identified by a given URL. The server comprises a processor, an operating system, a load balancing routine, and a redirector routine for  
10 managing HTTP connection requests to the Web site. The redirector routine is a front end process that runs in the server and includes means responsive to connection requests from client machines that initiate user sessions for associating each user session originating from a client  
15 machine with a given server through a unique session identifier. During each user session, connection requests originating from the client machine to the given URL are redirected to the given server.

The foregoing has outlined some of the more pertinent  
20 objects and features of the present invention. These objects should be construed to be merely illustrative of some of the more prominent features and applications of the invention. Many other beneficial results can be attained by applying the disclosed invention in a different manner or  
25 modifying the invention as will be described. Accordingly, other objects and a fuller understanding of the invention

may be had by referring to the following Detailed Description of the Preferred Embodiment.

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**BRIEF DESCRIPTION OF THE DRAWINGS**

For a more complete understanding of the present invention and the advantages thereof, reference should be made to the following Detailed Description taken in connection with the accompanying drawings in which:

**Figure 1** is a representative system in which the present invention is implemented;

**Figure 2** is a flowchart illustrating the conventional processing associated with an HTTP request from the Web client to the Web server shown in **Figure 1**;

**Figure 3** is a block diagram of a client machine connecting to a Web site comprising a server pool;

**Figure 4** is a state diagram illustrating the inventive functionality of the redirector routine; and

**Figure 5** is a flowchart illustrating the function of the redirector routine.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A known Internet client-server system is implemented is illustrated in **Figure 1**. A client machine **10** is connected to a Web server **12** via network **14**. For illustrative

5 purposes, network **14** is the Internet, an intranet, an extranet or any other known network. Web server **12** is one of a plurality of servers which are accessible by clients, one of which is illustrated by machine **10**. A representative client machine includes a browser **16**, which is a known  
10 software tool used to access the servers of the network. The Web server supports files (collectively referred to as a "Web" site) in the form of hypertext documents and objects. In the Internet paradigm, a network path to a server is identified by a so-called Uniform Resource Locator (URL).

15 A representative Web server **12** is an IBM Netfinity server comprising a RISC-based processor **18**, the AIX® operating system **20** and a Web server program **22**, such as Netscape Enterprise Server. The server **12** also includes a display **24** supporting a graphical user interface (GUI) for  
20 management and administration, and an Application Programming Interface (API) **23** that provides extensions to enable application developers to extend and/or customize the core functionality thereof through software programs including Common Gateway Interface (CGI) programs, plug-ins,

servlets, active server pages, server side include (SSI) functions or the like.

A representative Web client is a personal computer that is x86-, PowerPC®- or RISC-based, that includes an operating system such as IBM® OS/2® or Microsoft Windows '95, and that includes a Web browser, such as Netscape Navigator 4.0 (or higher), having a Java Virtual Machine (JVM) and support for application plug-ins or helper applications.

The Web server accepts a client request and returns a response. The operation of the server program 22 is governed by a number of server application functions (SAFs), each of which is configured to execute in a certain step of a sequence. This sequence, illustrated in **Figure 2** by way of background only, begins with authorization translation (AuthTrans) 30, during which the server translates any authorization information sent by the client into a user and a group. If necessary, the AuthTrans step may decode a message to get the actual client request. At step 32, called name translation (NameTrans), the URL associated with the request may be kept intact or it can be translated into a system-dependent file name, a redirection URL or a mirror site URL. At step 34, called path checks (PathCheck), the server performs various tests on the resulting path to ensure that the given client may retrieve the document. At step 36, sometimes referred to as object types (ObjectType), MIME (Multipurpose Internet Mail Extension) type information

(e.g., text/html, image/gif, etc.) for the given document is identified. At step 38, called Service (Service), the Web server routine selects an internal server function to send the result back to the client. This function can run the  
5 normal server service routine (to return a file), some other server function (such as a program to return a custom document) or a CGI program. At step 40, called Add Log (AddLog), information about the transaction is recorded.

Figure 3 is a block diagram illustrating the  
10 environment in which the present invention is implemented. In this illustration, client machine 42 makes HTTP requests to a Web site comprising a managing server 44, and a set of mirrored servers 46a-46n managed by the managing server. Managing server 44 may comprise one of the mirrored servers.  
15 Managing server 44 includes a load balancing routine 48 for keeping track of the load on each of the mirrored servers and for directing service requests to the servers according to a load balancing algorithm. According to the present invention, the managing server further includes a redirector  
20 routine 50 that provides the enhanced functionality of the present invention.

As will be seen, redirector routine 50 acts as a front end process for parsing client requests and for determining whether a given request represents the beginning or end of a  
25 "session." As used herein, a session represents a set of

connection-less transactions between a given user (at a client machine) and the Web site. For example, if the managing server is a bank Web site, the session involves a set of queries to the server from the user, together with  
5 the responses served from the servers. In this example, a user logs in and is recognized as being authorized to access given information (e.g., a bank account balance). According to the present invention, the redirector enables all of requests originating from the client machine to the site,  
10 and all of the information delivered to the client machine, to be served to and from the same server during a given "session." One of ordinary skill in the art will thus appreciate that this enables the load to be balanced on a per-session basis, as opposed to a per-connection basis as  
15 in the prior art.

This operation is now described with respect to the state diagram of **Figure 4**, together with the flowchart of **Figure 5**. Sequential steps are numbered in the state diagram. The routine begins at step 52 with the client  
20 making a request to initiate a session. Typically, this is a login request, which may occur, for example, by having the user access the Web site (through its URL) and then enter information into a CGI-based form. This is a conventional login transaction over the Internet. Returning to the  
25 flowchart, in step 52, the client machine thus issues an HTTP request (for example, <http://www.bank.com/login.html>)

to the managing server. At step 54, the redirector intercepts the request and recognizes that the user has requested the initiation of a session. Following (optional) entry and validation of a userid and password, the routine  
5 continues at step 56, wherein the redirector queries the load balancing routine to determine which of the servers in the set will service the session. This outcome of this test depends on the particular load balancing algorithm being implemented. As noted above, the present invention enables  
10 HTTP connection requests and associated server responses to be managed through one server of the set throughout the entire session.

At step 58, the redirector associates a session identifier with the session and then notifies the server (in  
15 this example, server S4) that has been selected to manage the session of the session identifier. Preferably, the session identifier is a unique number (e.g., an increasing sequential number). At step 60, server S4 records the session identifier in a session table 55. Each server in  
20 the server pool preferably has an associated session table 55 for storing session identifiers of the sessions being managed by that server. The redirector likewise includes an appropriate data structure 57 maintaining information about which server is managing which session. At step 62, the  
25 redirector returns an appropriate redirection response

(e.g., "302: URL has moved") to the client. This response also identifies the URL of the server and includes the session identifier, e.g.: "http://server 4 URL/session identifier/login.html. This is sometimes referred to herein  
5 as a "virtual" URL. This completes the redirection function.

The client then continues at step 64 by issuing a new HTTP connection request, using the URL passed from the managing server during step 62. This redirection process is  
10 typically an automatic function carried out by the browser in response to the 302 response. The routine then continues at step 66 with the server S4 serving the requested data. All data returned to the client contains the session identifier as part of the URL base. Throughout the  
15 remainder of the session, all HTTP connection requests from this particular client machine are managed through server S4. This is illustrated at step 68 in the flowchart.

A test is performed repeatedly at step 70 to determine whether the session is to be terminated. Typically, this  
20 request is identified by the redirector because the user has taken some action that generates a given logoff request. Thus, for example, the redirector has parsed the input HTML stream and recognized the following request: "http://server 4 URL/session identifier/logoff.html". At this point in the  
25 routine, namely, at step 72, the server S4 deletes the session identifier from the session table 55 and performs

the requested logoff action. Deletion of the session identifier is sometimes referred to as "inactivating" the identifier because, once the session identifier is removed from the table, the client machine is no longer explicitly  
5 coupled to the server that, up until that time, had been handling the connection requests originating from that machine during the user session.

The routine then continues at step 74 to return a logoff screen to the client machine. The server then  
10 notifies the redirector that the user associated with the session identifier has logged off. At step 76, the redirector releases the server S4 from the session, thus making the server available to handle a new session from another user.

15 Thus, the redirector maintains a running count of the number of sessions being managed by each server in the pool, as well as the identification of the actual session identifiers being managed at each server. As a user completes his or her session, the server that has been  
20 managing the session becomes available to the redirector (and, thus, the load balancing routine) to service another set of connection requests from another user. Thus, load balancing is achieved on a per-session, as opposed to a per-connection, basis. This provides significant advantages  
25 over the prior art.

In particular, a given user may now undertake a set of transactions and be assured that all such transactions are



managed by the same server. By implementing the redirection function, the user is assured that he or she may carry out a set of transactions without having to login repeatedly to the server. This is quite advantageous as the transactions  
5 are connection requests that are communicated in a connection-less (i.e. a "stateless") operating environment. By adding the virtual URL to the redirection request, the target server has the capability to count actual user sessions and thus impose an upper limit of users instead of  
10 connections. Another benefit is that if the user cannot bookmark a page in the middle of a session because the virtual URL is short-lived (i.e. it only lasts as long as the session lasts). This ensures that the user is forced to back to the beginning URL to begin a new session, thus  
15 preventing restarts in the middle of a particular session. The redirector provides a consistent session flow.

The above-described functionality preferably is implemented in software running on the managing server. There is no requirement to modify the client-side software  
20 as the redirection to the virtual URL takes place automatically. The redirector thus may be plug-in enabled code, preferably a Java servlet. The functionality thus is implemented in software executable in a processor, namely, as a set of instructions (program code) in a code module  
25 resident in the random access memory of the computer. Until required by the computer, the set of instructions may be stored in another computer memory, for example, in a hard

disk drive, or in a removable memory such as an optical disk (for eventual use in a CD ROM) or floppy disk (for eventual use in a floppy disk drive), or downloaded via the Internet or other computer network.

5           In addition, although the various methods described are conveniently implemented in a general purpose computer selectively activated or reconfigured by software, one of ordinary skill in the art would also recognize that such methods may be carried out in hardware, in firmware, or in  
10 more specialized apparatus constructed to perform the required method steps.

          Further, as used herein, a Web "client" should be broadly construed to mean any computer or component thereof directly or indirectly connected or connectable in any known  
15 or later-developed manner to a computer network, such as the Internet. The term Web "server" should also be broadly construed to mean a computer, computer platform, an adjunct to a computer or platform, or any component thereof. Of course, a "client" should be broadly construed to mean one  
20 who requests or gets the file, and "server" is the entity which downloads the file.

          Having thus described my invention, what I claim as new and desire to secure by Letters Patent is set forth in the following claims.

25

## CLAIMS

1. A method for managing connection requests to a pool of servers identified by a given URL, comprising the steps of:

5 in response to a connection request from a given client machine that initiates a session, associating a session identifier with a given server in the pool;

using the session identifier to redirect the connection request to the given server; and

10 during the session, redirecting to the given server any additional connection requests from the given client machine.

2. The method as described in Claim 1 wherein the step of using the session identifier includes generating a virtual URL.

3. The method as described in Claim 2 wherein the virtual URL comprises a URL in the connection request  
20 modified to include the session identifier.

4. The method as described in Claim 1 wherein the session identifier is incorporated in data returned from the given server to the client machine.

25

5. The method as described in Claim 1 further including the step of:

in response to a connection request from the given client machine that terminates the session, inactivating the session identifier.

6. The method as described in Claim 1 wherein the given client machine includes a browser.

10 7. The method as described in Claim 1 wherein each of the servers in the pool supports a similar set of objects.

8. The method as described in Claim 1 wherein the session identifier is associated with a given server as a function of a load balancing protocol.

9. A method for managing connection requests to a pool of servers, comprising the steps of:

responsive to connection requests from client machines that initiate user sessions, associating each user session  
5 originating from a client machine with a given server in the pool in accordance with a load balancing protocol; and  
during the user session, redirecting to the given server any additional connection requests originating from the client machine.

10

10. The method as described in Claim 9 wherein the associating step comprises:

generating a virtual URL by modifying a given URL to include a session identifier;

15 using the virtual URL to redirect the connection request to the given server.

11. The method as described in Claim 10 further including the step of:

20 inactivating the virtual URL upon completion of the user session.

12. The method as described in Claim 10 wherein all data returned from given server to the client machine  
25 includes the session identifier.

13. The method as described in Claim 9 wherein each of the servers in the pool supports a similar set of given objects.

5 14. The method as described in Claim 9 wherein each client machine includes a Web browser. ✓

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15. A computer program product in a computer-readable medium for managing connections requests to a pool of servers, comprising:

means responsive to connection requests from client  
5 machines that initiate user sessions for associating each user session originating from a client machine with a given server in the pool in accordance with a load balancing protocol; and

means operative during each user session for  
10 redirecting to the given server any additional connection requests originating from the client machine.

16. The computer program product as described in Claim  
15 wherein the associating means comprises:

15 means for generating a virtual URL by modifying a given URL to include a session identifier; and

means for redirecting a given connection request to the given server using the virtual URL.

20 17. The computer program product as described in Claim  
16 further including:

means for inactivating the virtual URL upon completion of the user session.

25

18. A server for managing a pool of servers at a Web site identified by a given URL, comprising:

a processor;

5 an operating system;

a load balancing routine; and

a redirector routine for managing HTTP connection requests to the Web site, comprising:

means responsive to connection requests from client machines that initiate user sessions for associating each user session originating from a client machine with a given server in the pool in accordance with the load balancing routine; and

10

means operative during each user session for redirecting to the given server any additional connection requests originating from the client machine.

15

19. The server as described in Claim 18 wherein the means for associating comprises:

20

means for generating a virtual URL by modifying the given URL to include a session identifier; and

means for redirecting a given connection request to the given server using the virtual URL.

25



20. The server as described in Claim 19 wherein the redirector further includes:

means for inactivating the virtual URL upon completion of the user session.

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21. A method of managing a pool of servers at a Web site identified by a given URL, comprising the steps of:

responsive to connection requests from client machines that initiate user sessions, associating each user session  
5 originating from a client machine with a server in the pool;

distributing the user sessions across the pool of servers according to a load balancing protocol; and

during a given user session initiated from a given client machine, serving content to the given client machine  
10 only from its associated server.

22. A method of managing a pool of servers at a Web site identified by a given URL, comprising the steps of:

during each user session initiated from a given client machine, temporarily redirecting all connection requests  
5 originating from the client machine to a given server in the pool; and

distributing the user sessions across the pool of servers according to a load balancing protocol.

10

## USING VIRTUAL URLs FOR LOAD BALANCING

## ABSTRACT OF THE DISCLOSURE

A method, computer program product and server for use managing connection requests to a pool of servers identified  
5 by a given URL. The method begins in response to a connection request from a given client machine that initiates a user session for associating a session identifier with a given server in the pool. The session identifier is then used to generate a "virtual" URL that  
10 redirects the connection request to the given server. Thereafter, any additional connection requests issued from the given client machine during the user session are redirected to the given server so that all content is served to the client from the same location. When the user session  
15 terminates, the virtual URL is inactivated and the given server is returned to the pool so that it can then be assigned a new user session to manage.

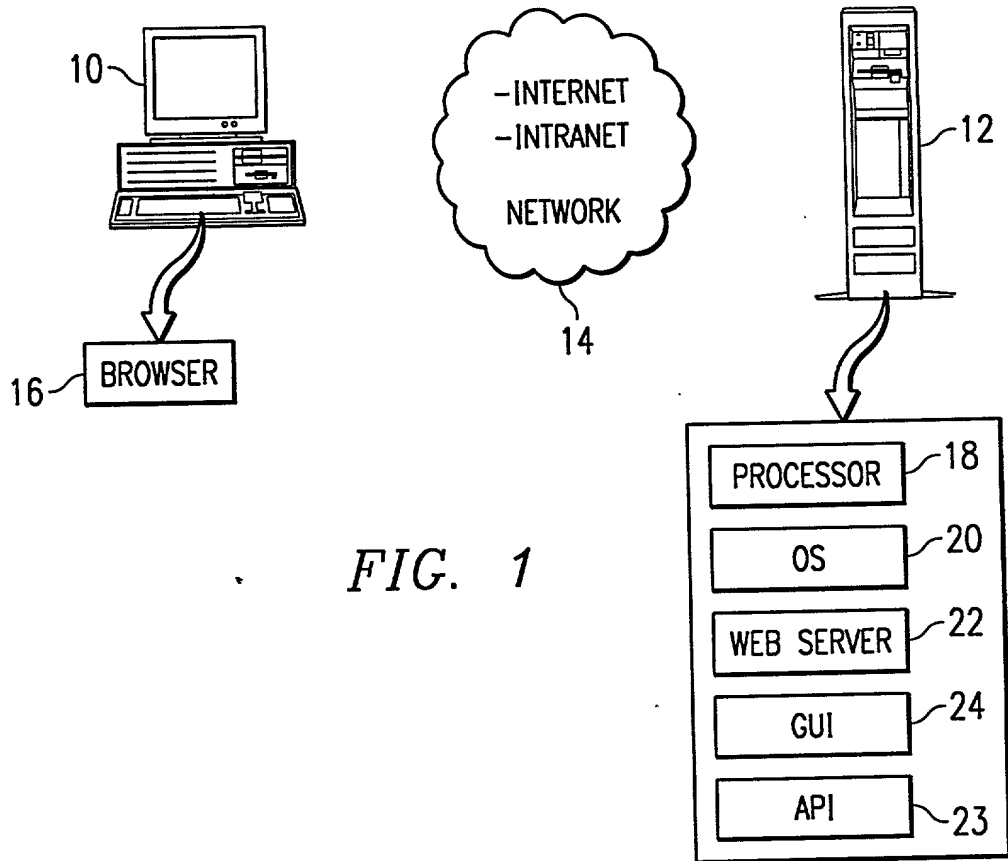


FIG. 1

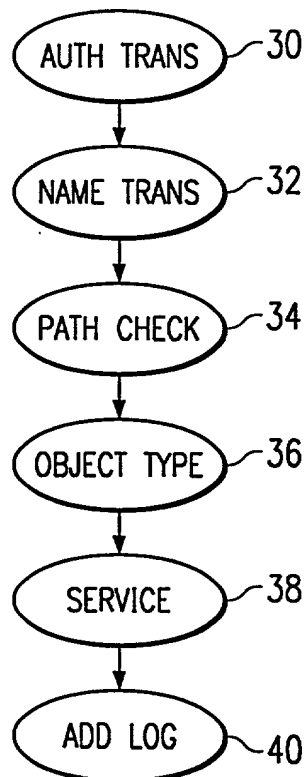


Figure 2

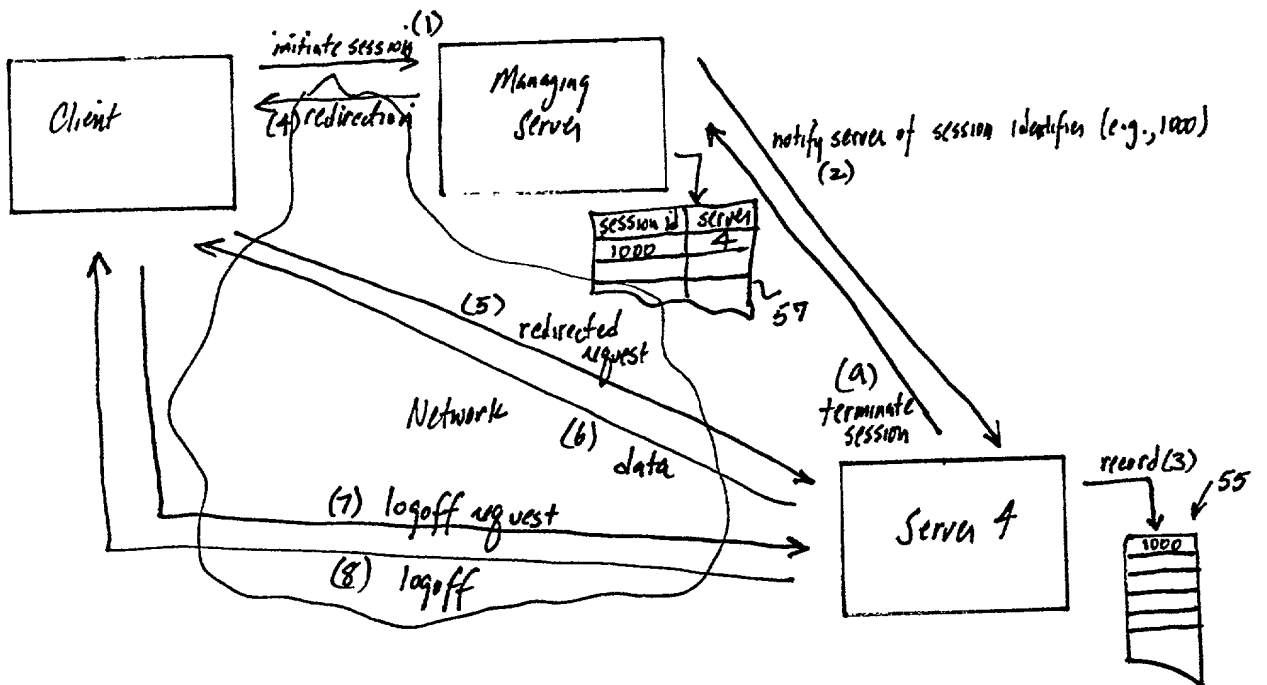
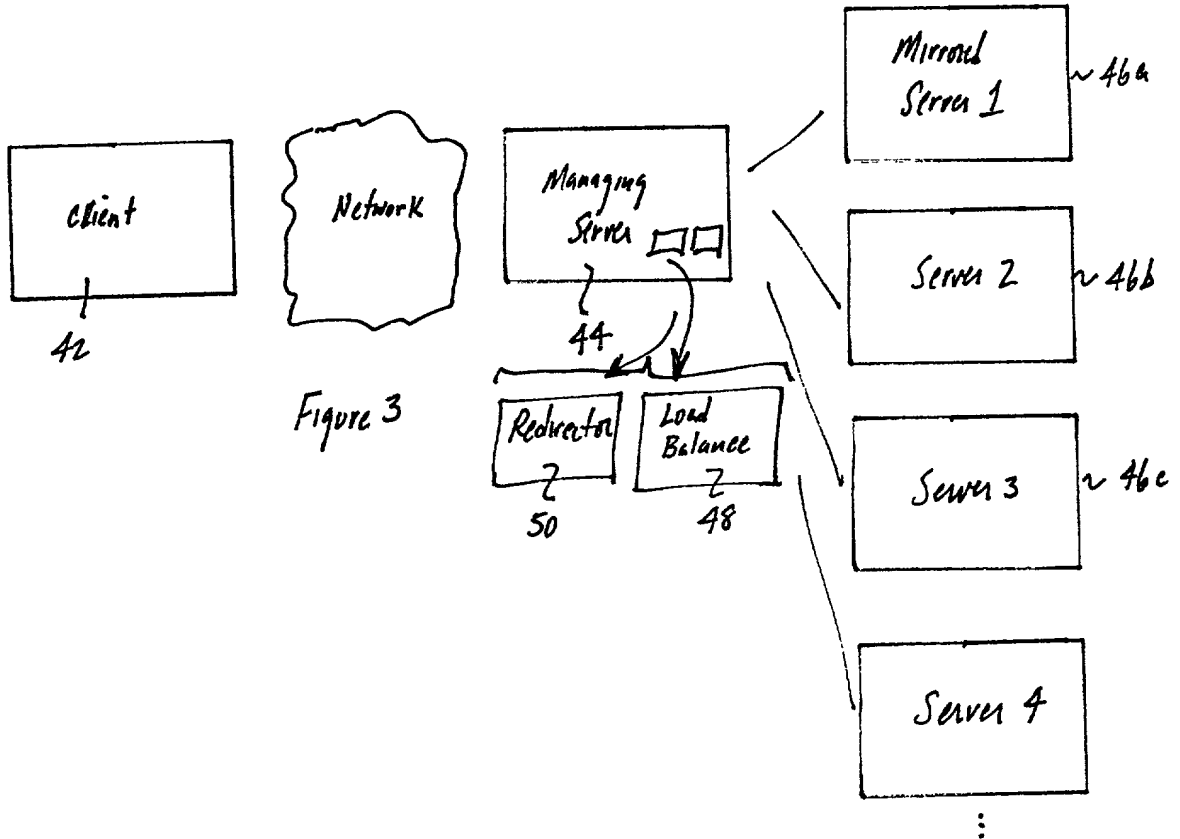


Figure 4

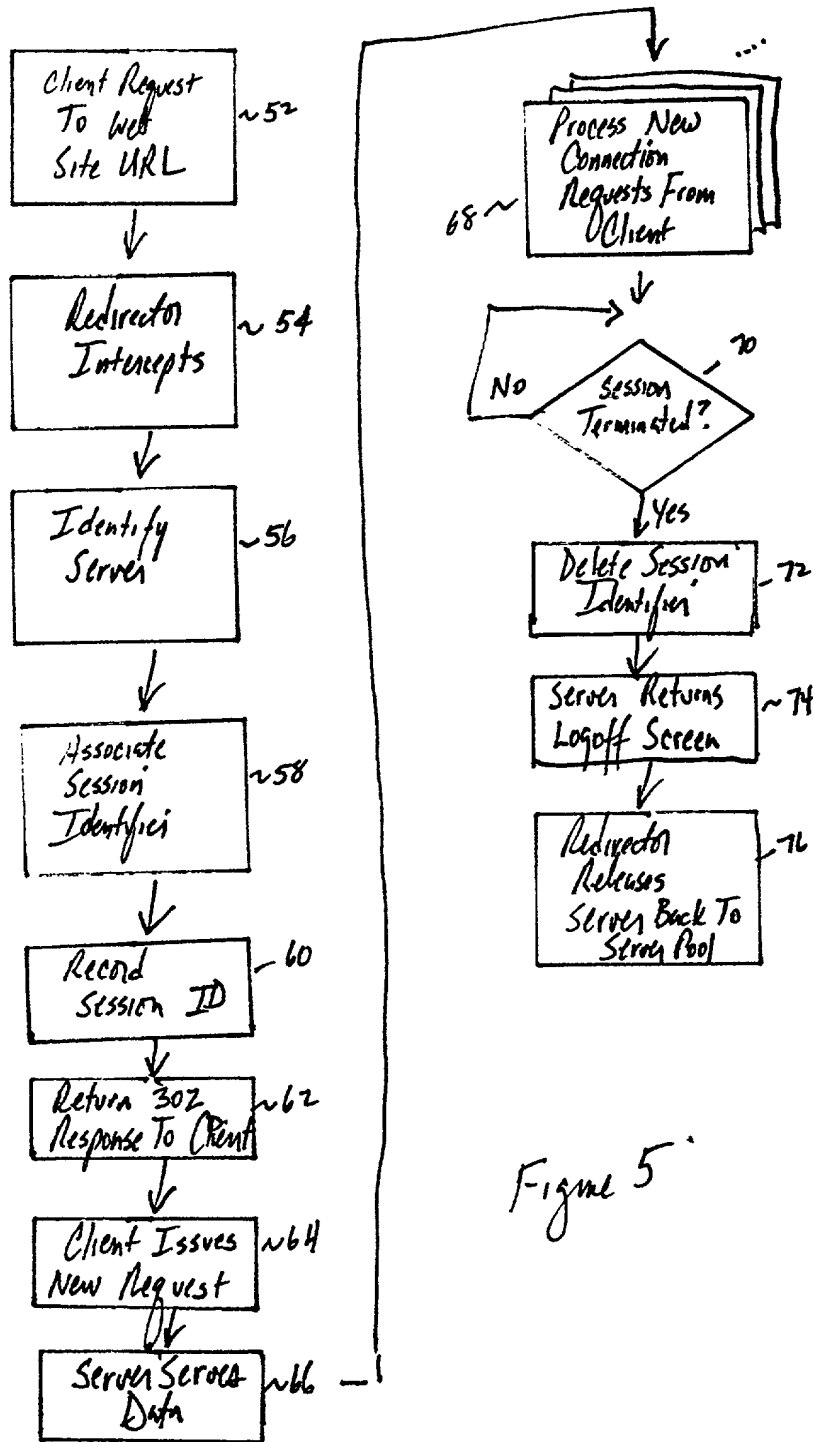


Figure 5

## DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

### USING VIRTUAL URLs FOR LOAD BALANCING

the specification of which (check one):

- ☒ is attached hereto.
- ☐ was filed on \_\_\_\_\_;  
as Application Serial No. \_\_\_\_\_  
and which was amended on \_\_\_\_\_ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s):

Priority Claimed

\_\_\_\_\_  
(Number)

\_\_\_\_\_  
(Country)

\_\_\_\_\_  
(Day/Month/Year)

\_\_\_ Yes \_\_\_ No

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information material to the patentability of this application as defined in Title 37, Code of Federal Regulations, § 1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:



(Application Serial #)

(Filing Date)

(Status)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorneys and/or agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

John W. Henderson, Jr., Reg. No. 26,907; James H. Barksdale, Jr., Reg. No. 24,091; Thomas E. Tyson, Reg. No. 28,543; Robert M. Carwell, Reg. No. 28,499; Jeffrey S. LaBaw, Reg. No. 31,633; Douglas H. Lefevre, Reg. No. 26,193; Casimer K. Salys, Reg. No. 28,900; David A. Mims, Jr., Reg. No. 32,708; Richard A. Henkler, Reg. No. 39,220; Anthony V. England, Reg. No. 35,129; Volel Emile, Reg. No. 39,969; Leslie A. Van Leeuwen, Reg. No. 42,196; Christopher A. Hughes, Reg. No. 26,914; Edward A. Pennington, Reg. No. 32,588; John E. Hoel, Reg. No. 26,279; Joseph C. Redmond, Jr., Reg. No. 18,753; Marilyn S. Dawkins, Reg. No. 31,140; David H. Judson, Reg. No. 30,467, and Douglas A. Sorensen, Reg. No. 31,570.

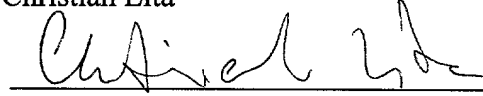
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